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SUPERELASTIC SCATTERING OF SPIN-POLARIZED ELECTRONS FROM OPTICALLY PUMPED SODIUM

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In an effort to more accurately characterize inelastic electron-atom scattering, we have studied the spin dependence in the superelastic scattering process

$$Na\ (3^2P_{3/2},\ F=3) + e^- \rightarrow Na\ (3^2S_{1/2}) + e^- + 2.1\ eV\ .$$

These results provide significant new information about the scattering process and provide a very stringent test for theoretical calculations.

The apparatus consists of crossed beams of spin-polarized electrons and optically pumped sodium atoms, with an energy selective detector for electrons superelastically scattered through some angle. The polarized electron beam is produced by photoemission from negative electron affinity GaAs using circularly polarized light. The atomic sodium beam, collimated from an effusive source, is oriented and spin-polarized by the laser optical pumping process.

Four scattering signals are recorded at each energy and scattering angle, one for each of the four relative orientations of electron and atom spins. From these four signals, we construct three relative quantities which, together with the absolute cross section, completely characterize the scattering process.[1] The first quantity is the ratio, r, between the triplet and singlet contributions to the scattering. The other two quantities, $L_\perp^t$ and $L_\perp^s$, are the angular momenta transferred to the atom, perpendicular to the scattering plane, in collisions via the triplet and singlet scattering channels, respectively.

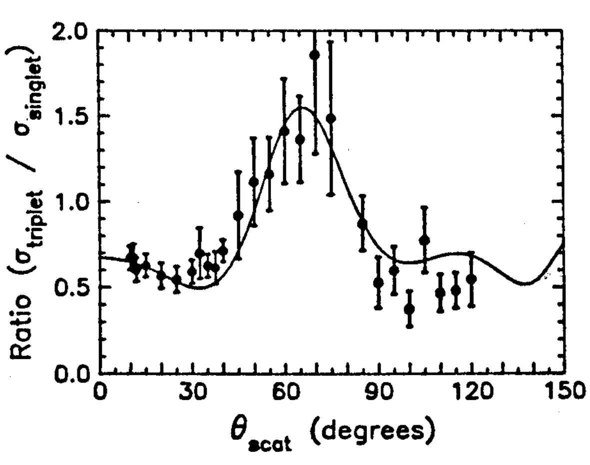

Figure 1. Ratio of Triplet to Singlet Scattering at 2.0 eV incident energy.

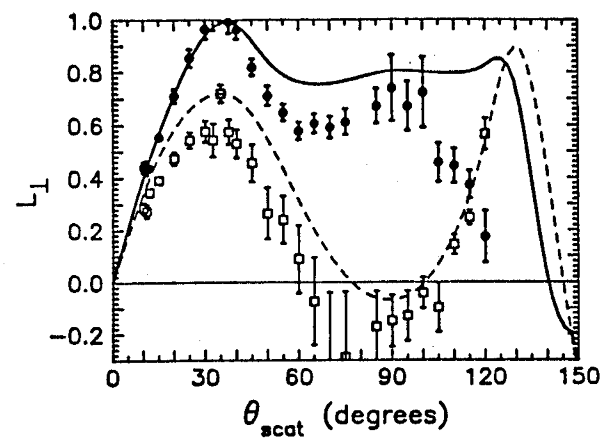

Figure 2. $L_\perp^s$ (Ф̄) and $L_\perp^t$ (ɸ) at 2.0 eV incident energy.

Our experimental results at an incident electron energy of 2.0 eV are shown in Figures 1 and 2. In both figures the points are our results with error estimates of one standard deviation from counting statistics. The smooth curves are the 4-state close-coupling results of Moores and Norcross.[2] At this low incident energy (below the ionization potential), the agreement between theory and experiment is generally quite good, though the theory somewhat overestimates $L_\perp^s$ at small angles and significantly overestimates $L_\perp^t$ at large angles. Similar results at higher incident energy will provide a stringent test for theoretical calculations.

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References

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2. D. L. Moores, and D. W. Norcross, J. Phys. B5, 1482, (1972).